Experimental methods in chemical engineering: pH

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Authors:


Yanet Villasana
Universidad Regional Amazónica IKIAM


Nooshin Moradi


Carlos Navas-Cárdenas
Yachay Tech


Gregory Scott Patience
Polytechnique Montréal

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Abstract

All chemical, biochemical, and biological processes depend on pH. Since the 1920s, when the first electrode was introduced to determine the concentration of hydrogen ions, pH measurement techniques have been evolving to fit the application at laboratory and industrial scales. These techniques include conventional methods based on electrical and optical methods like glass electrodes and variants. Most of the current methods still require a probe to be immersed in a solution. However, biomedical applications in the development stages involve non-invasive probes that measure hydrogen ion concentration or electrical conductivity, which is related to the concentration of all ions. Instruments also measure both these properties simultaneously for water analysis, agriculture, and electrochemistry. pH drops by as much as 90% increasing temperature from 5-45 °C (for MgSO4, NaCl, and an acetate buffer). The repeatability is excellent for a glass electrodes, which continues to be the measurement technique of choice for most laboratories, with a standard deviation of better than 0.08% for low molar concentrations (0.05 M) that increases to above 0.2% at high molar concentrations (> 0.7 M). Besides the standard potentiometric methods, emerging techniques include ion-sensitive field transistors, pH imaging, conductometric, acoustic microsensors, microcantilevers, and spectroscopy. In the first 6 months of 2020, Web of Science indexed almost 10 000 articles that mentioned pH as a keyword; most were in environmental sciences, multidisciplinary chemistry, and chemical engineering. Here, we review the latest developments, including spectroscopic methods, progress towards miniaturization, in particular for bio-medical applications like skin and bio-fluids, unconventional sampling, repeatability, and uncertainty.